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Mouthpart morphology of six freshwater species of Cymothoidae (Isopoda) from Amazonian fish compared to that of three marine forms, with the proposal of Artystonenae subfam. nov.

by

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Abstract

The mouthpart morphology of six Amazonian freshwater species of Cymothoidae (Isopoda) was compared to that of three marine forms. The freshwater species were: *Braga cichlae* SCHIÖDTE & MEINERT, 1881; *Braga nasuta* SCHIÖDTE & MEINERT, 1881; *Riggia brasiliensis* SZIDAT & SCHUBART, 1960; *Vanamea symmetrica* (VAN NAME, 1925) THATCHER, 1993; *Asotana magnifica* THATCHER, 1988; and *Artystone minima* THATCHER & CARVALHO, 1988. The marine forms used were: *Elthusa vulgaris* (STIMPSON, 1857); *Ceratothoa gaudichaudii* (MILNE EDWARDS, 1810); and *Nerocila orbignyi* (GUERIN-MENEVILLE, 1832). The marine species were found to have biting mandibles with shearing blades and sharp incisors. Mandibles of the freshwater species lacked such structures. The mandibles of *Riggia* and *Artystone* were seen to have numerous lateral recurved spines which may aid these genera in penetrating to the body cavities of their hosts. Maxillules of freshwater species had five recurved spines near their tips (3-4 terminal and 1-2 subterminal) whereas in marine forms, it was more usual to find four spines, all terminal. The maxillae of most of the species studied were bilobed and bore 2 spines near the tip of each lobe. Exceptions were: *Asotana*, in which the maxillae are undivided and provided with a few spinules and *Ceratothoa* which has trilobed maxillae with numerous small spines. The maxillipeds were found to have two large recurved spines on the terminal article of the palp. Exceptions were: *Ceratothoa* and *Nerocila* in which that article was provided with several spines. On the basis of comparative mouthpart morphology, it is suggested that the freshwater species studied should all be included in Artystonenae subfam. nov.

Keywords: **Cymothoid mouthparts, fish parasites, isopods, Amazon, Brazil, new subfamily.**

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Introduction

Mouthpart morphology in arthropods has been found to be most useful as an indicator of feeding habits, micro-habitats and phylogeny. Among cymothoid isopod parasites of fish, however, these structures have largely been ignored. SCHIÖDTE (1868) pointed out the importance of understanding the cymothoid mouthparts, but SCHIÖDTE & MEINERT (1879-1884), in their classic monograph, failed to illustrate such structures. Some more recent papers, however, give information on the mouthparts, including the mandible. For example, those of marine forms are treated by: BRUCE (1990), BRUCE & BOWMAN (1989), TRILLES (1965, 1979, 1980), WILLIAMS & WILLIAMS (1987) and of South American freshwater species by BOWMAN (1986), THATCHER (1988, 1993a, b, 1995, 1996), THATCHER & CARVALHO (1988). Apparently, no comparative study of cymothoid mouthparts has been made perhaps because they were thought to be too similar to warrant it.

The cymothoid mandible has been especially ignored and misinterpreted. The older works do not illustrate the mandibles. RICHARDSON (1905) presented outline drawings of mandibles for some species but for many others, only the mandibular palp was shown. LEIGH-SHARPE (1937) described a freshwater species (now known as *Asotana splendida*) from Ecuador and illustrated some of the mouthparts. Unfortunately, his drawing was mislabled as follows: maxilla 1 was called the mandible; maxilla 2 was referred to maxilla 1; the mandibular palp was said to be maxilla 2; and some of the structures shown could be either labial lobes or mandibles.

BRUSCA (1981) has pointed out the difficulty in separating the mandibles from the labium and has cited several authors that in his opinion have drawn the mandible with part of the labium attached. This may well be the explanation for the unusual bilobed "mandible" shown for *Artystone trysibia* in LEMOS DE CASTRO & PEREIRA MACHADO FILHO (1946).

The present study is offered in the hope that it may provide a better basis for the understanding of the phylogeny and systematics of these curious animals and clarify doubts concerning the morphology of their mouthparts.

Material and methods

The freshwater cymothoids were removed from fish hosts in the Brazilian Amazon. Specimens of *Nerocila* came from marine fish captured on the coast of Rio Grande do Sul State in Southern Brazil. Comparative material of *Elthusa vulgaris* and *Ceratothoa gaudichaudii* was kindly provided by RICHARD C. BRUSCA of the San Diego Natural History Museum, San Diego, California. Mouthparts were separated under a dissecting microscope using needles and forceps. Permanent slides were made of these parts by means of the phenol-balsam method explained in THATCHER & CARVALHO (1988). Drawings were made with the aid of a compound microscope equipped with a drawing tube. All scale bars indicate sizes in micrometers (μm).

Results

Mandibles (Figs. 1-7)

The marine species studied showed mandibles with bladelike cutting processes and projecting incisors (Figs. 4-7). These findings agree well with those reported in recent studies, such as that of BRUSCA (1981).

In contrast, the mandibles of *Braga* spp. and *Vanamea symmetrica* (Figs. 1-2) were rounded and blunt, lacking entirely the cutting blade and incisor. The mandible of *Asotana magnifica* was also found to be similar but was shorter and wider.

A third type of mandible was found in *Artystone minima* and in *Riggia brasiliensis* (Fig. 3). This kind of mandible is more slender and is "slipper-shaped". It also lacks the cutting plate and incisor but has numerous spines laterally, near the tip.

All species studied had 3-segmented mandibular palps. The palps of marine species were frequently longer than those of freshwater forms, however, and were provided with more terminal setae.

Remarks: Mandibular morphology may be indicative of phylogenetic relationships, feeding habits or habitat. The marine species generally have mandibles with cutting plates and incisors and therefore may be considered to have "biting" mandibles. Many of these species live on the surface of their fish hosts where they bite holes in the epidermis.

The present study recognizes two different types of mandibles among South American freshwater cymothoids. One of these might be called a "crushing mandible" and it is found in *Braga* spp., *Vanamea symmetrica* and *Asotana magnifica*. These species all live on top of the tongues of their hosts and probably feed on semiliquid material regurgitated from the host's stomach.

Another type of mandible was that found in *Riggia* spp. and *Artystone* spp. The species of both of these genera penetrate into the body cavities of host fish. The mandibles that these species possess might be considered as "tearing mandibles" since they are provided with lateral spines near their tips which are probably used to tear apart host tissue to gain entrance to the body cavity.

Maxillules (Figs. 8-16)

All three marine species studied showed terminal recurved spines on the maxillules (Figs. 14-16). The usual number was four, although occasionally five were present (Fig. 16).

All of the freshwater species seen had five recurved spines on the maxillules. The most common arrangement for these spines was to have three on the tip and two subterminal.

Maxillae (Figs. 17-25)

Most cymothoids appear to have bilobed maxillae with two spines on each lobe. The number of spines is variable, however, and some specimens may have an extra one (Fig.

21). In the case of *Artystone* and *Riggia* (Figs. 19, 20), the recurved spines are larger or more laterally directed. This may relate to the fact that these isopods tunnel into the fish's body cavity.

Of the species studied, only two had strikingly different maxillae. *Asotana magnifica* has maxillae that are not lobed and are provided with tiny spinules only. *Ceratothoa gaudichaudii*, on the other hand, has maxillae that are trilobed and two of the lobes bear numerous spines.

Labia (Figs. 26-32)

The cymothoid labium has received scant mention in the world's literature. The labium (termed tongue by SCHIÖDTE, 1968) is a bi-lobed or quadri-lobed structure below and closely associated with the mandibles. In marine cymothoids, the labium is an inconspicuous membranous organ which is limited in its forward extension by the labrum (Figs. 27, 29).

In the freshwater cymothoids considered here, the labia were found to be either bi-lobed (Fig. 28) or quadri-lobed (Figs. 31, 32). The longer lobes are as heavily chitinized as the mandibles and are provided with lateral spinules (Fig. 32). These lobes are attached to the bases of the mandibular blades and probably move with them.

Labra (Figs. 26, 27)

The cymothoid labrum is a structure attached to the clypeus that forms the roof of the mouth or its anterior margin. In the marine forms studied, the labrum was large and doubled under the mandibles (Fig. 27). In the freshwater species considered here, the labrum projected straight forward and did not cover the mandibles (Fig. 26).

Maxillipeds (Figs. 33-38)

The maxillipeds studied all consisted of a 3-segmented palp attached to a basis and in young, or male, specimens, that arrangement was more visible (Fig. 36). In adult females, the proximal segment of the palp and the basis both grow to form large flattened plates, sometimes provided with setae. The tip of the terminal segment is frequently equipped with two large spines. In *Ceratothoa gaudichaudii* and *Nerocila orbignyi*, however, several additional spines were found (Figs. 34, 38).

Conclusions

Comparative mouthpart morphology clearly shows that the South American freshwater cymothoids are more similar to each other than they are to the marine species. Presumably, this could reflect a common origin.

According to the classification of cymothoids proposed by SCHIÖDTE & MEINERT (1884) and extended by TRILLES (1973), the species studied would be

arranged as follows: Cymothoidae; Cymothoinae; *Paracymothoa tholoceps*. Ceratothoinae; *Ceratothoa gaucichaudii*. Lironecinae (= Livonecinae); *Elthusa vulgaris, Vanamea symmetrica* and *Artystone minima*. Anilocridae; Anilocrinae; *Nerocila orbignyi, Braga nasuta, B. cichlae* and *Asotana magnifica*.

Knowledge of the mouthpart morphology makes the above classification untenable and the following scheme is therefore proposed: Cymothoidae; Artystonenae subfam. nov.; *Artystone minima, Asotana magnifica, Braga nasuta, B. cichlae, Vanamea symmetrica, Paracymothoa tholoceps* and *Riggia brasiliensis*. Ceratothoinae; *Ceratothoa gaudichaudii*; Anilocrinae; *Nerocila orbignyi* and *Elthusa vulgaris*.

Artystonenae subfam. nov. is here by proposed to include all of the South American freshwater genera studied. The new subfamily is characterized as having mandibles that lack incisors and maxillules with five recurved spines.

Resumo

A morfologia das partes bucais de seis espécies de Cymothoidae (Isopoda) d'água doce foi comparado com as de três formas marinhas. As espécies d'água doce foram: *Braga cichlae* SCHIÖDTE & MEINERT, 1881; *Braga nasuta* SCHIÖDTE & MEINERT, 1881; *Riggia brasiliensis* SZIDAT & SCHUBART, 1960; *Vanamea symmetrica* (VAN NAME, 1925) THATCHER, 1993; *Asotana magnifica* THATCHER, 1988; and *Artystone minima* THATCHER & CARVALHO, 1988. As formas marinhas estudadas foram: *Elthusa vulgaris* (STIMPSON, 1857); *Ceratathoa gaudichaudii* (MILNE EDWARDS, 1810); and *Nerocila orbignyi* (GUERIN-MENEVILLE, 1832). Foi observado que as formas marinhas têm mandíbulas apropriadas para morder, providas de pranchas cortantes e processos incisores agudos. As mandíbulas das espécies d'água doce careciam de tais estruturas. Foi observado que as mandíbulas de *Riggia* and *Artystone* têm numerosos espinhos que são recurvados e laterais. Os espinhos provavelmente ajudam estes géneros em penetrar até a cavidades corporais dos seus hospedeiros. As maxílulas das espécies d'água doce tinham cinco espinhos recurvados pertos às extremidades (sendo 3-4 terminais e 1-2 subterminais). Nas formas marinhas, foi mais comum encontrar quatro espinhos, todos terminais. As maxilas de quase todas as espécies estudadas foram bilobadas e com 2 espinhos pertos das extremidades de cada lóbulo. Exceções foram: *Asotana*, no qual as maxilas não são divididas e que têm vários espínhulos terminalmente; também, *Ceratathoa* que está com maxilas trilobados provistos de numerosos espínhulos. As maxilípedes geralmente tinha dois espinhos grandes no artículo terminal do palpo. Eceções foram: *Ceratathoa* and *Nerocila* que tinham esse artículo provisto de vários espinhos. Na base da morfologis comparada das partes bucais, é sugerido que as espécies d'água doce estudadas devem ser incluidas na Artystonenae subfam nov.

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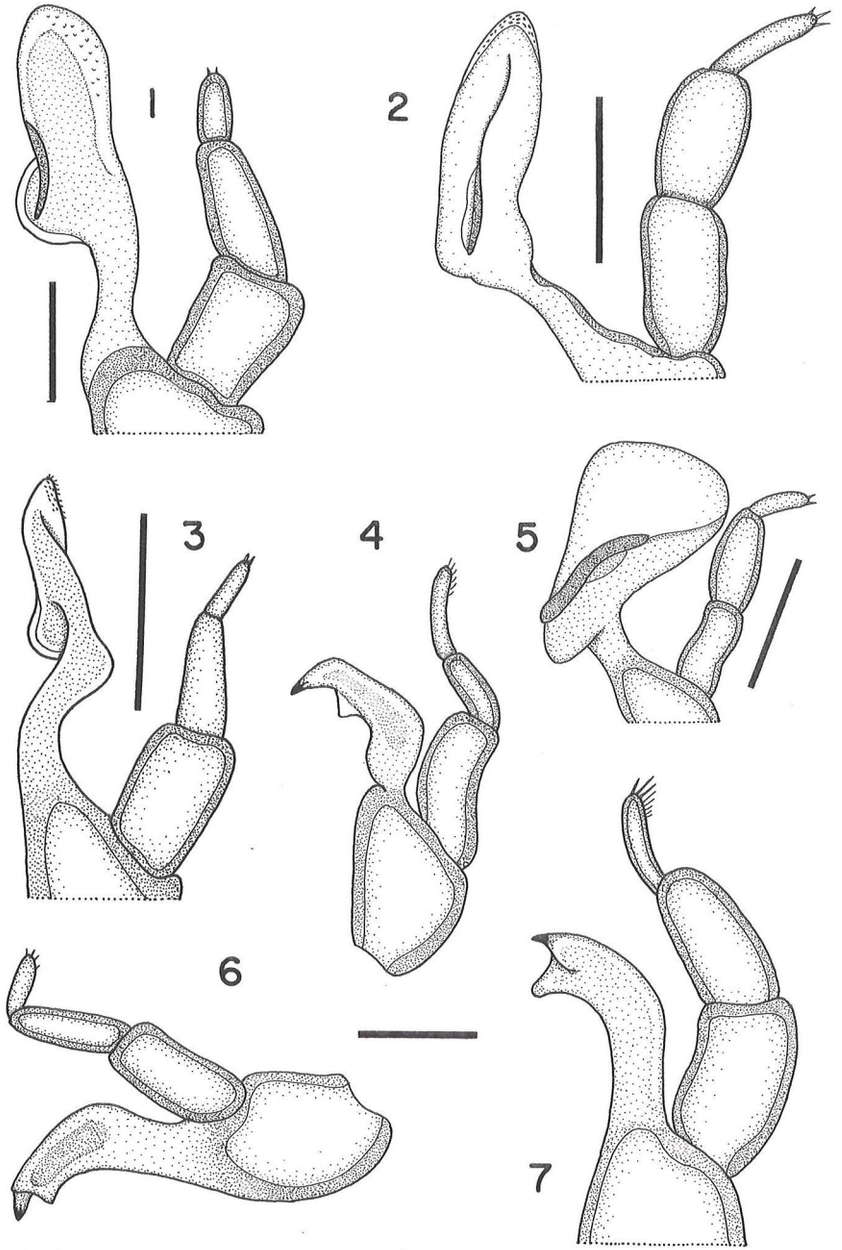
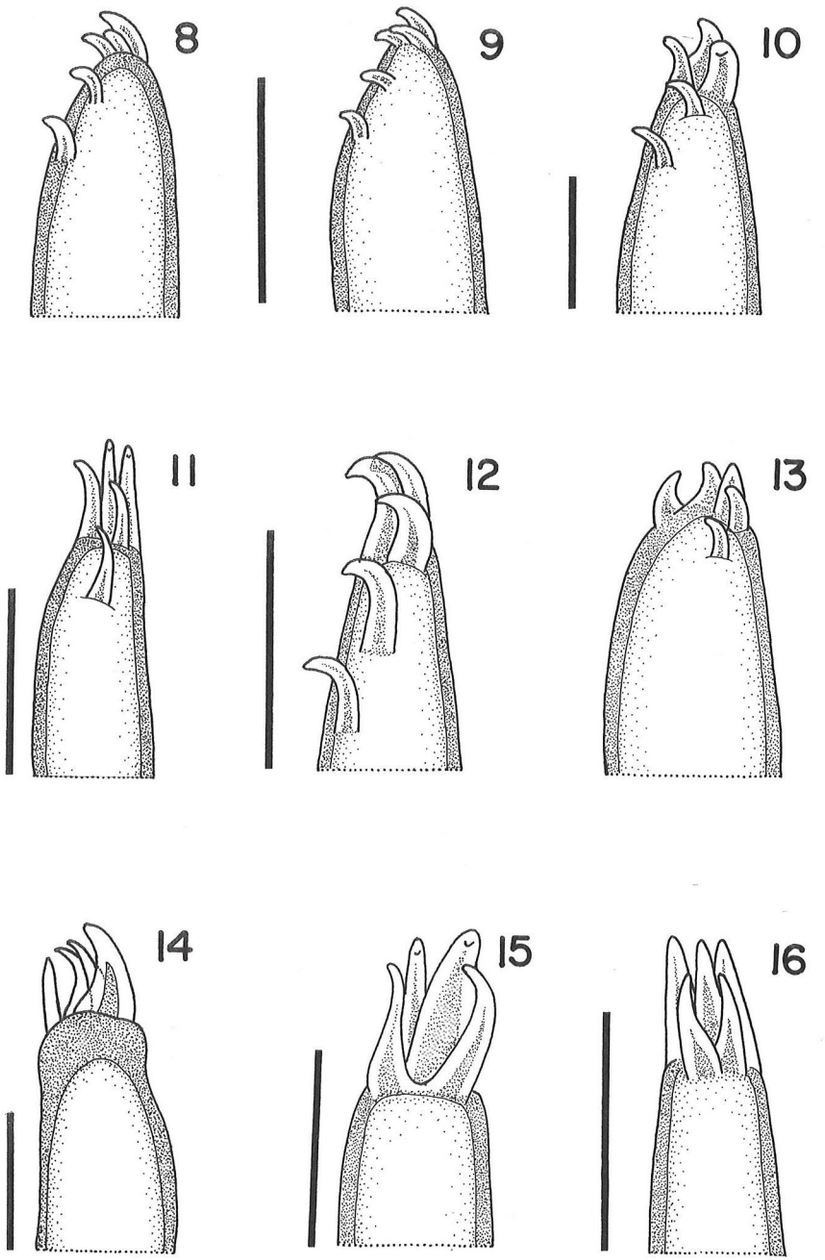
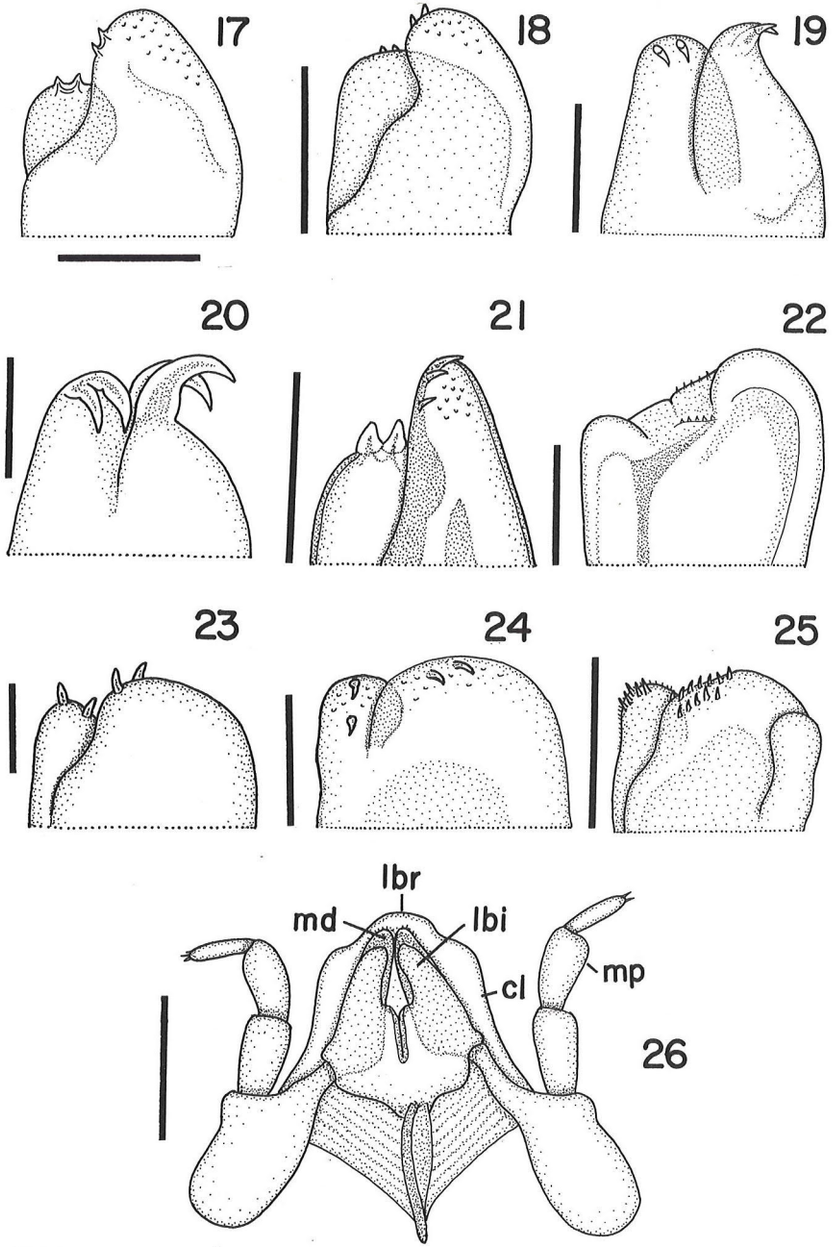


Figs. 1-7:
Mandibles with palps. **1**: *Braga nasuta*; **2**: *Vanamea symmetrica*; **3**: *Riggia brasiliensis*; **4**: *Nerocila orbignyi*; **5**: *Asotana magnifica*; **6**: *Elthusa vulgaris*; **7**: *Ceratothoa gaudichaudii*; Scale bars for 1-4, 6 & 7 = 500 µm; 5 = 1,000 µm.



Figs. 8-16:
Maxillules. **8**: *Braga cichlae*; **9**: *Braga nasuta*; **10**: *Riggia brasiliensis*; **11**: *Artystone minima*; **12**: *Vanamea symmetrica*; **13**: *Asotana magnifica*; **14**: *Elthusa vulgaris*; **15**: *Nerocila orbignyi*; **16**: *Ceratathoa gaudichaudii*. Scale bars for 8, 9, 13 & 16 = 100 µm; for 11 = 50 µm.



Figs. 17-26:
Maxillae. **17**: *Braga cichlae*; **18**: *Braga nasuta*; **19**: *Riggia brasiliensis*; **20**: *Artystone minima*; **21**: *Vanamea symmetrica*; **22**: *Asotana magnifica*; **23**: *Elthusa vulgaris*; **24**: *Nerocila orbignyi*; **25**: *Ceratathoa gaudichaudii*.
26: Mouthpart dissections: *Vanamea symmetrica*; cl = clypeus; lbi = labium; lbr = labrum; md = mandible; mp = mandibular palp.
Scale bars for 17, 18, 22, 25 & 26 = 500 µm; for 19, 21 & 24 = 250 µm; for 20 = 50 µm.

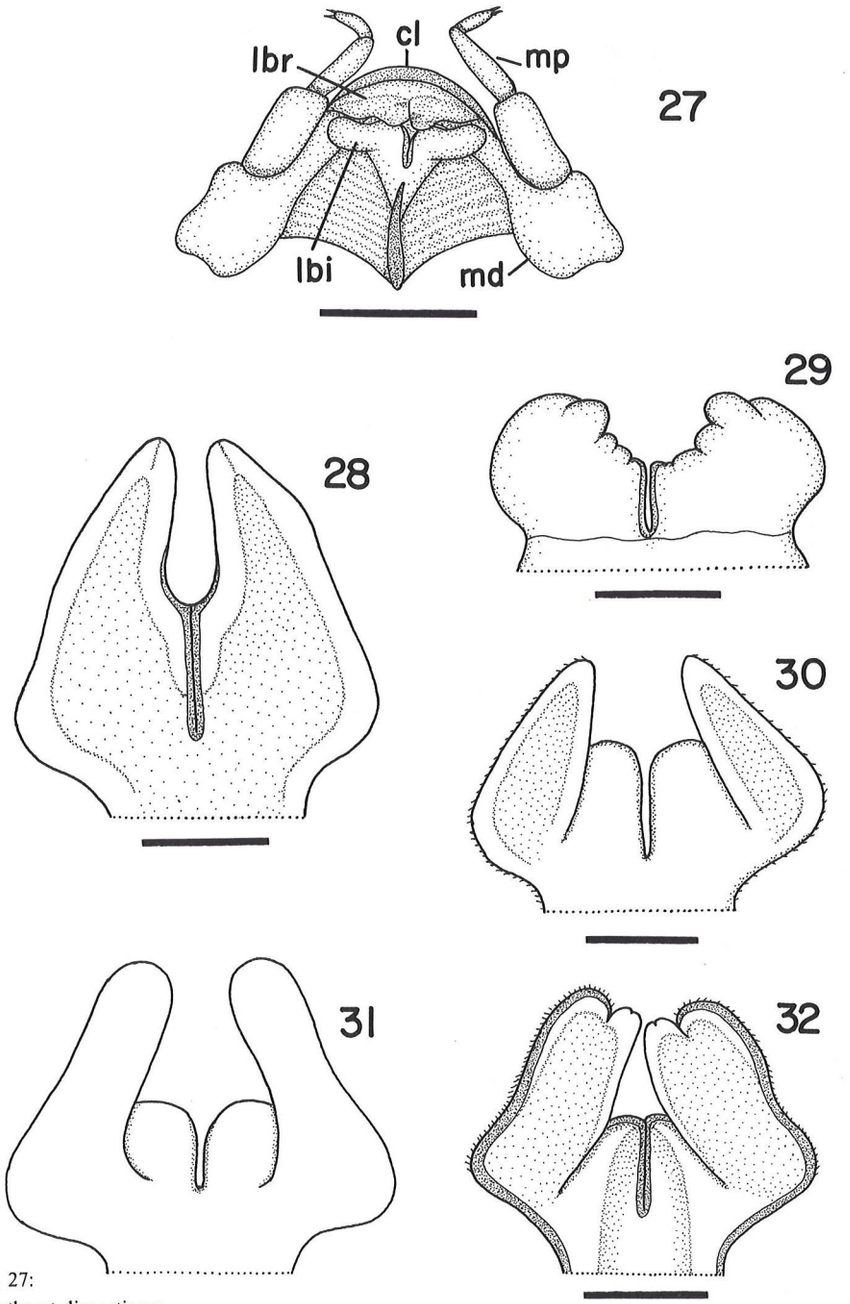
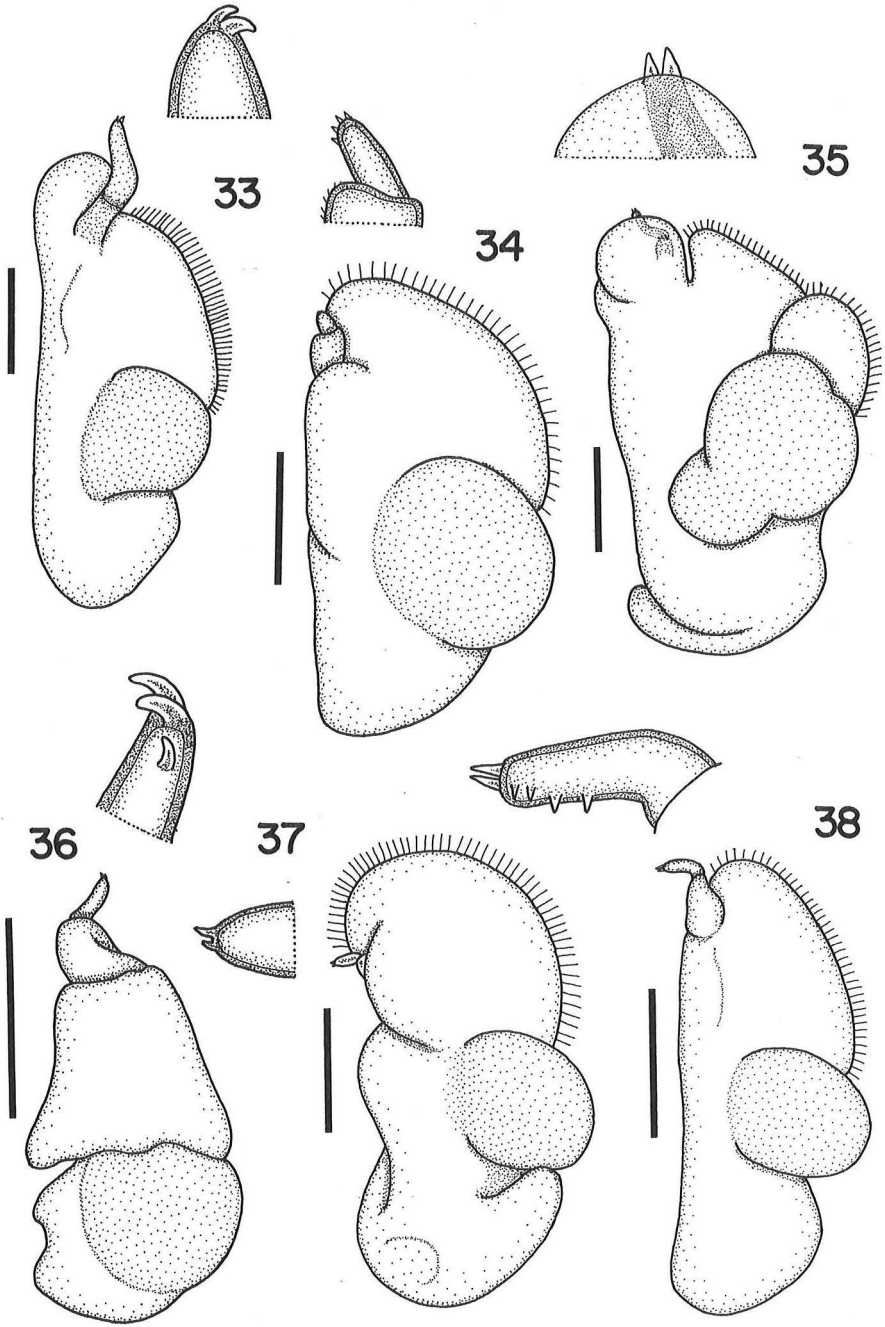


Fig. 27:
Mouthpart dissections:
27: *Elthusa vulgaris*; cl = clypeus; lbi = labium; lbr = labrum; md = mandible; mp = mandibular palp.
Figs. 28-32:
Labia: **28**: *Vanamea symmetrica*; **29**: *Ceratothoa gaudichaudii*; **30**: *Nerocila orbignyi*; **31**: *Paracymothoa tholoceps* (modified after BOWMAN, 1986); **32**: *Braga cichlae*.
Scale bars for 27, 28 & 30 = 500 µm.



Figs. 33-38:
Maxillipeds: **33**: *Braga nasuta*; **34**: *Ceratothoa gaudichaudii*; **35**: *Riggia brasiliensis*; **36**: *Elthusa vulgaris* (♂); **37**: *Elthusa vulgaris* (♀); **38**: *Nerocila orbignyi*.
Scale bars = 1,000 μm.